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SPECIFICATION

TO ALL WHOM IT MAY CONCERN:

BE IT KNOWN THAT WE, Yuta Aono, a citizen of Japan residing at Kawasaki-shi, Kanagawa, Japan and Kimio Watanabe, a citizen of Japan residing at Kawasaki-shi, Kanagawa, Japan have invented certain new and useful improvements in

TRANSMISSION APPARATUS, ORDER WIRE TRANSMISSION SYSTEM AND
ORDER WIRE MONITORING METHOD

of which the following is a specification : -

TRANSMISSION APPARATUS, ORDER WIRE
TRANSMISSION SYSTEM AND ORDER WIRE
MONITORING METHOD

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BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention generally relates to transmission apparatuses, order wire transmission systems and order wire monitoring methods, and more particularly to a transmission apparatus which includes functions for transmitting and receiving multiplexed signals in various kinds of networks and functions for transmitting and receiving order wire signals, an order wire transmission system which uses such a transmission apparatus, and an order wire monitoring method for monitoring quality and the like of an order wire line.

2. Description of the Related Art

FIG. 1 is a system block diagram generally showing an order wire transmission system. In FIG. 1, transmission apparatuses A and B are connected via a radio or cable line, transmission apparatuses C and D are connected via a radio or cable line, and transmission apparatuses E and F are connected via a radio or cable line. Each of the transmission apparatuses A through F includes functions for transmitting and receiving a main signal with another transmission apparatus, and functions for transmitting and receiving an order wire signal. The transmission apparatuses B, C and E are located within a single office S, and the order wire signal is branched and combined in the office S.

FIG. 2 is a system block diagram for explaining an important part of a conventional transmission apparatus. In FIG. 2, a transmission apparatus 71 corresponds to the transmission

apparatus B shown in FIG. 1. The transmission apparatus 71 includes an optical or radio transmitter and receiver section 72 transmits and receives an optical signal or a radio signal, a multiplexing and demultiplexing section 73, and an order wire section 74. The order wire section 74 includes a codec section 75, an analog branching and combining section 76, an office Dual Tone Multi Frequency (DTMF) transmitting and retrieving section 77, and a 2-wire/4-wire (2W/4W) converter 78. A telephone set 79 is connected to the 2W/4W converter 78. The transmission apparatuses C and D have the same construction as the transmission apparatus B (71), and are connected to the transmission apparatus B (71). In FIG. 2, the illustration of transmission paths for the multiplexed signals exchanged among the transmission apparatuses B, C and D is omitted.

The multiplexing and demultiplexing section 73 carries out a multiplexing process and a demultiplexing process in conformance with a multiplexing system such as Plesiochronous Digital Hierarchy (PDH), Synchronous Digital Hierarchy (SDH) and the like. For example, the order wire signals are multiplexed in specific time slots in the case of the PDH, and the order wire signals are multiplexed by section overhead bytes E1 and E2 in the case of the SDH. Accordingly, the multiplexing and demultiplexing section 73 is constructed to multiplex and demultiplex the order wire signals depending on the multiplexing system employed.

When connecting to an optical line, the optical or radio transmitter and receiver section 72 has optical-to-electrical converting functions and optical wavelength multiplexing and demultiplexing functions. On the other hand, when connecting to a radio line, the optical or radio transmitter and

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employed.

For example, when communicating between the transmission apparatuses A and F shown in FIG. 1 via an order wire line, the branching and combining of the order wire signals are carried out via the analog branching and combining section 76 in the intermediate transmission apparatus B as shown in FIG. 2. In addition, in the transmission apparatuses B and E which are located between the transmission apparatuses A and F, the telephone sets are put into the on-hook state. For example, if the telephone set 79 of the transmission apparatus B, which is located between the transmission apparatuses A and F, is put into the off-hook state, the communication using the order wire signals cannot be made between the transmission apparatuses A and F. But in this state, a communication using the order wire signals is possible with the transmission apparatus A or the transmission apparatus F using this telephone set 79.

In a system which transmits multiplexed signals by connecting a plurality of transmission apparatuses by a line such as the cable line, optical line and radio line, the order wire line corresponding to one channel is prepared for making a prearranged communication between the transmission apparatuses. This order wire line is shared by each of the transmission apparatuses, so as to enable the prearranged communication between arbitrary transmission apparatuses. In such a system, even when the multiplexed main signal can be transmitted and received, a connection error may exist in one transmission apparatus with respect to the order wire line, in which case the order wire line cannot be connected between the transmission apparatuses which are located on both ends of this one transmission apparatus.

In addition, the order wire signals which are demultiplexed from the multiplexed main signal are converted into analog signals by the codec section 75, branched by the analog branching and combining section 76 and distributed to the telephone set and the adjacent transmission apparatuses. Moreover, the analog order wire signals are combined by the analog branching and combining section 76, and converted into digital signal by the codec section 75. In other words, the digital-to-analog conversion is carried out every time the order wire signals are branched, and the analog-to-digital conversion is carried out every time the order wire signals are combined. As a result, quantization errors are accumulated by the conversions which are carried out repeatedly, and a failure may be generated in the prearranged communication due to this quantization error accumulation. When such a failure occurs, it is

In addition, the order wire signals which are demultiplexed from the multiplexed main signal are converted into analog signals by the codec section 75, branched by the analog branching and combining section 76 and distributed to the telephone set and the adjacent transmission apparatuses. Moreover, the analog order wire signals are combined by the analog branching and combining section 76, and converted into digital signal by the codec section 75. In other words, the digital-to-analog conversion is carried out every time the order wire signals are branched, and the analog-to-digital conversion is carried out every time the order wire signals are combined. As a result, quantization errors are accumulated by the conversions which are carried out repeatedly, and a failure may be generated in the prearranged communication due to this quantization error accumulation. When such a failure occurs, it is

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SUMMARY OF THE INVENTION

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signals; a branching and combining section branching and combining analog order wire signals; a 2-wire/4-wire converter which is capable of coupling to a telephone set; and a monitoring processor which

5 includes a storage section storing transmitting and received data, and an order wire monitoring controller, the order wire monitoring controller controlling transmission of test data stored in the storage section to an order wire line, controlling

10 storage of test data received via the order wire line to the storage section, and controlling transmission and reception of one of the received test data, analyzed data of the received test data, and judgement data indicative of a judgement result

15 of a comparison of the analyzed data and threshold values. According to the transmission apparatus of the present invention, it is possible to monitor the quality of the order wire line using a simple construction.

20 A further object of the present invention is to provide an order wire transmission system which couples a plurality of transmission apparatuses via multiplexed lines which multiplex and transmit main and order wire signals, wherein:

25 each transmission apparatus includes a multiplexing and demultiplexing section and an order wire section, the order wire section comprising a codec section carrying out an analog-to-digital conversion and a digital-to-analog conversion with respect to order

30 wire signals, a branching and combining section branching and combining analog order wire signals, a 2-wire/4-wire converter which is capable of coupling to a telephone set, and a monitoring processor; the monitoring processor including a storage section

35 storing transmitting and received data, and an order wire monitoring controller which controls transmission of test data stored in the storage

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section to an order wire line, controls storage of
test data received via the order wire line to the
storage section, and controlling transmission of the
received test data and analyzed data of the received
5 test data; and the order wire monitoring controller
including a function of receiving and identifying
control information which specifies transmission or
reception of the test data, a function of
transmitting the test data from the storage section
10 when specified to transmit test data, a function of
receiving and storing the test data in the storage
section when specified to receive the test data, and
a function of controlling transmission of one of the
received test data stored in the storage section,
15 the analyzed data of the received test data, and
judgement data indicative of a judgement result of a
comparison of the analyzed data and threshold values,
after a predetermined time or at a specified time.
According to the order wire transmission system of
20 the present invention, it is possible to monitor the
quality of the order wire line, without having to
send a maintenance or service person to each of the
transmission apparatuses which are generally located
distant from each other.

25 Another object of the present invention is
to provide an order wire monitoring method for
monitoring a quality of an order wire line which
couples a plurality of transmission apparatuses via
multiplexed lines which multiplex and transmit main
30 and order wire signals, comprising the steps of:
specifying a transmission apparatus which is to
transmit test data as a specified transmitting
apparatus, and a transmission apparatus which is to
receive test data as a specified receiving
35 apparatus; transmitting the test data from the
specified transmitting apparatus to the order wire
line in response to a start of test; receiving and

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temporarily storing the test data in the specified receiving apparatus; transmitting to the specified transmitting apparatus one of the stored received test data, analyzed data of the received test data, and judgement data indicative of a judgement result of a comparison of the analyzed data and threshold values, after a predetermined time or at a specified time; and monitoring, in the specified transmitting apparatus, the quality of the order wire line between the specified transmitting apparatus and the specified receiving apparatus. According to the order wire monitoring method of the present invention, it is possible to monitor the quality of the order wire line, without having to send a maintenance or service person to each of the transmission apparatuses which are generally located distant from each other. Further, the quality of the order wire line between desired transmission apparatuses may be monitored from an arbitrary transmission apparatus.

Other objects and further features of the present invention may be apparent from the following detailed description when read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a system block diagram generally showing an order wire transmission system;

FIG. 2 is a system block diagram for explaining an important part of a conventional transmission apparatus;

FIG. 3 is a diagram for explaining an embodiment of an order wire transmission system according to the present invention;

FIG. 4 is a system block diagram showing an important part of a first embodiment of a transmission apparatus according to the present

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FIG. 5 is a system block diagram for explaining a monitoring processor of the first embodiment;

FIG. 7 is a time chart for explaining the operation of a specified test data transmitting office;

FIG. 9 is a system, block diagram showing an important part of a third embodiment of the transmission apparatus according to the present invention;

FIG. 11 is a system block diagram for
20 explaining a test data analysis control;

FIGS. 13A and 13B are diagrams for explaining test data analysis;

FIGS. 15A and 15B are diagrams for explaining analysis and judgement of test data;

FIG. 17 is a flow chart for explaining a judging logic;

35 FIG. 19 is a time chart for explaining the
operation of a test data receiving office.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 3 is a diagram for explaining an embodiment of an order wire transmission system according to the present invention. In FIG. 3, NE1 through NE10 indicate transmission apparatuses, and L1 through L5 indicate lines. It is assumed for the sake of convenience that the lines L1 through L5 are radio lines, but it is of course possible to use cable lines or optical lines for the lines L1 through L5. Further, it is assumed for the sake of convenience in FIG. 3 that the transmission apparatuses NE2, NE3 and NE7 form a single office, the transmission apparatuses NE4 and NE5 form a single office, and the transmission apparatuses NE8 and NE9 form a single office.

Each of the transmission apparatuses NE1 through NE10 includes a monitoring processor which is connected to an order wire line. For example, in response to an instruction from a monitoring control terminal TE which is connected to the transmission apparatus NE4, the monitoring processor operates so that processes such as transmission of test data via the order wire line, analysis of received test data, and returning results of the analysis are carried out between specified transmission apparatuses. The monitoring processor also has a function of prestoring the test data. In FIG. 3, a transmitting direction of the test data is indicated by a solid line arrow, and a transmitting direction of the analyzed data or judgement data is indicated by a phantom line arrow.

For example, the monitoring control terminal TE specifies the transmission apparatus NE2 as a test data transmitting office (specified test data transmitting transmission apparatus), and specifies the transmission apparatus NE1 as a test data receiving office (specified test data receiving

transmission apparatus). When the monitoring control terminal TE instructs a test of the order wire line to start, the test data stored in the monitoring processor of the transmission apparatus

5 NE2 are transmitted to the transmission apparatus NE1 via the order wire line. The transmission apparatus NE1 receives and analyzes the test data, and obtains judgement data indicating judgement

10 results related to a setting of the order wire line, existence of an connection error, accumulation of quantization error and the like. The judgement data are returned to the transmission apparatus NE2. The transmission apparatus NE2 transfers the judgement

15 data to the monitoring control terminal TE via the transmission apparatuses NE3 and NE4, so that a maintenance or service person can monitor the state or normality of the order wire line between the transmission apparatuses NE1 and NE2.

In addition, the monitoring control

20 terminal TE is capable of specifying the transmission apparatus NE6, for example, as the test data receiving office, so as to carry out the prearranged communication test. In other words, the analog audio signals from a telephone set of the

25 transmission apparatus NE4 are converted into digital audio data, and prearranged communication data are transmitted via the order wire line, and the transmission apparatus NE6 demultiplexes the prearranged communication data from the multiplexed

30 signals and temporarily stores the prearranged communication data in a storage section of the monitoring processor. Depending on an instruction included in control information which is received from the transmission apparatus NE4 or, after a

35 predetermined elapses, the audio data of the prearranged communication data stored in the storage section are looped back and transmitted via the

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FIG. 4 is a system block diagram showing an important part of a first embodiment of a transmission apparatus according to the present

invention.

FIG. 4 shows three transmission apparatuses 1-1, 1-2 and 1-3, and the construction of the transmission apparatus 1-1. The transmission apparatus 1-1 includes a transmitter and receiver section 2, a multiplexing and demultiplexing section 3, and an order wire section 4. The order wire section 4 includes a codec section 5, an analog branching and combining section 6, an office DTMF transmitting and retrieving section 7, a 2W/4W converter 8, and a monitoring processor 9. The monitoring processor 9 includes an order wire monitoring controller 11, a transmitting and received data storage section 12, a data analyzer 13, an analyzed data storage section 14, and a comparing and judging section 15. A telephone set 16 is connected to the 2W/4W converter 8 of the order wire section 4 within the transmission apparatus 1-1.

FIG. 4 shows a case where the connection and arrangement of the transmission apparatuses 1-1, 1-2 and 1-3 are similar to those of the transmission apparatuses NE2, NE3 and NE7 shown in FIG. 3. Each of the transmission apparatuses 1-1 through 1-3 have the order wire section 4 which is provided with the monitoring processor 9 having the same construction. The transmission apparatuses 1-1 through 1-3 are connected to each other via the analog branching and combining section 6 of the order wire section 4. The illustration of the transmission paths for the multiplexed signals exchanged among the transmission apparatuses 1-1 through 1-3 is omitted in FIG. 4. As described above, the order wire section 4 includes the codec section 5, the analog branching and combining section 6, the office DTMF transmitting and retrieving section 7 and the 2W/4W converter 7 which are similar to those of the conventional transmission apparatus shown in FIG. 2.

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Hence, the prearranged communication can be started between the transmission apparatus 1-1 and the specified transmission apparatus via the order wire line.

5 FIG. 5 is a system block diagram showing the monitoring processor 9 of this first embodiment. In FIG. 5, the order wire monitoring controller 11 is formed by a processor (CPU) 21. This CPU 21 is connected to a data analysis and comparison judging
10 program storage 22, an analyzed data storage 23, a transmitting and received data storage 24, a test data communication processor 25 and a control information communication processor 26, via an internal bus 20. The control information
15 communication processor 26 transmits and receives the control information which is multiplexed and demultiplexed by the multiplexing and demultiplexing section 3, via a control channel. The test data communication processor 25 has functions for
20 transmitting and receiving the test data via the order wire line.

 The data analysis and comparison judging program storage 22 stores a program for realizing the functions of the data analyzer 13 and the
25 comparing and judging section 15 shown in FIG. 4. The analyzed data storage 23 and the transmitting and received data storage 24 respectively correspond to the analyzed data storage section 13 and the transmitting and received data storage section 12
30 shown in FIG. 4. In addition, the data analysis and comparison judging program storage 22, the analyzed data storage 23 and the transmitting and received data storage 24 may be formed by RAMs or the like.

 FIG. 6 is a time chart for explaining the
35 operation of this first embodiment. More particularly, FIG. 6 shows timings of the operation between an intra-office and an inter-office, where

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30 In addition, the specified test data transmitting office sets the test data in the transmitting and received data storage section 12, and returns a set complete to the transmitting source. Of course, it is possible to prestore the
35 test data in the transmitting and received data storage section 12, and return a transmission enable state as the set complete. When the set complete is

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section 15 compares the analyzed data and threshold values, and judges the quality of the order wire line. The judgement data indicative of this judgement are stored in the transmitting and
5 received data storage section 12.

Under the control of the order wire monitoring controller 11, the judgement data are transmitted to the specified test data transmitting office as judgement results, and the judgement
10 results are received by the monitoring control terminal TE. The maintenance or service person judges the quality of the order wire line between the specified test data transmitting office and the specified test data receiving office, based on
15 display contents and the like of the received judgement results. Accordingly, it becomes possible to monitor the order wire line between arbitrary transmission apparatuses, at an arbitrary transmission apparatus.

FIG. 8 is a time chart for explaining the operation of a second embodiment of the transmission apparatus according to the present invention. In this second embodiment, the basic construction of the transmission apparatus is the same as that of
20 the first embodiment shown in FIG. 4, and an illustration thereof will be omitted.

FIG. 8 shows a case where the order wire line is monitored using audio signals. As indicated by ①, the maintenance or service person makes
30 inputs to specify the test data receiving office and to set the loop-back, using the monitoring control terminal TE. Hence, control information including information related to the specified test data receiving office and the loop-back setting is
35 transmitted under the control of the order wire monitoring controller 11. The specified test data receiving office makes the setting so that the test

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The maintenance or service person confirms the setting complete which is received, and makes inputs to start the test as indicated by ② in FIG. 8. After transmitting control information related to this starting of the test to the specified test data receiving office, the maintenance or service person makes an audio signal input from the telephone set 16 which is connected to the order wire section 4, as indicated by ③. The audio signals are converted into digital signals by the codec section 5, and are multiplexed by the multiplexing and demultiplexing section 3 and transmitted as order wire signals.

The maintenance or service person confirms the reception complete which is received, and inputs a loop-back instruction as indicated by ④ in FIG. 8. In the specified test data receiving office, the audio data stored in the transmitting and received data storage 12 are read under the control of the order wire monitoring controller 11, in response to the loop-back instruction. The read audio data are input to the multiplexing and demultiplexing section 3, and are transmitted to the order wire line. On the other hand, in the specified test data

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The monitoring processor 39 includes an order wire monitoring controller 41, a received data storage section 42a, a transmitting data storage section 42b, a data analyzer 43, an analyzed data storage section 44, and a comparing and judging section 45. A telephone set 46 is connected to the 2W/4W converter 38 of the order wire section 34. In addition, an external interface 47 is connected to the switching circuit 40 of the order wire section 34.

Similarly as in the case of the first embodiment of the transmission apparatus shown in FIG. 4, the illustration of the transmission path of the multiplexed signals is omitted in FIG. 9. In addition, the monitoring processor 39 shown in FIG. 9 has a construction similar to that of the monitoring processor 9 shown in FIG. 4, except that regions of the transmitting and received data storage section 12 are divided into the received data storage section 42a and the transmitting data storage section 42b. FIG. 9 shows a case where another transmission apparatus 31 and the external interface 47 are connected to the analog branching and combining section 36.

The switching circuit 40 which is connected between the analog branching and combining section 36 and the external interface 47 is controlled by the order wire monitoring controller 41. When digital signals, that is, test data, are input from the external interface 47, the switching circuit 40 is switched so as to input the test data to the multiplexing and demultiplexing section 33 as the order wire signals. On the other hand, when inputting analog signals, that is, the test data, the switching circuit 40 is switched so as to input the test data to the codec section 35 and convert the test data into digital signals.

through (S5), the order wire monitoring controller 41 stores the test data which are received via the communication processor 51 into the received data storage section 42a. Further, by carrying out the loop-back control depending on the instruction from the specified test data transmitting office, the order wire monitoring controller 41 reads the stored test data from the received data storage section 42a and transmits the read test data via the communication processor 51.

The loop-back control described above is not limited to the case where the audio signals are used as the test data. In addition, such a loop-back control can also be made by a transmission apparatus having the construction shown in FIG. 4. Moreover, the loop-back control of the step (S4) may be made in response to the instruction from the specified test data transmitting office or, after a predetermined elapses from the time when the reception of the test data ends in the specified test data receiving office by transmitting the test data under the control of the order wire monitoring controller 41.

FIG. 11 is a system block diagram for explaining a test data analysis control. FIG. 11 shows the data analyzer 44 in addition to the elements shown in FIG. 10. In FIG. 11, the specified test data receiving office carries out the following steps (S11) through (S15). Under the control of the order wire monitoring controller 41, the step (S11) sets the reception, the step (S12) starts the test, the step (S13) receives the test data, the step (S14) analyzes the received test data, and the step (S15) analyzes the test data model. By carrying out the steps (S11) through (S13), the test data which are received via the communication processor 51 are stored in the received data storage

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section 42a. In addition, by carrying out the steps (S14) and (S15), the data analyzer 44 analyzes the test data stored in the received data storage section 42a, and analyzes the test data (mode) stored in the transmitting data storage section 42b.

FIG. 12 is a system block diagram for explaining a test data judging control. In FIG. 12, the analyzed data storage section 44 shown in FIG. 9 is formed by a region 44b for storing the analyzed data of the model test data, and a region 44a for storing the analyzed data of the received test data. The comparing and judging section 45 makes the comparison and judgement with respect to the analyzed data, so as to judge the quality of the order wire line and the like. In this case, when the test data are predetermined, it is possible to obtain the corresponding analyzed data in advance, and prestore the analyzed data in the region 44b of the analyzed data storage section 44.

FIGS. 13A, 13B, 14A and 14B are diagrams for explaining test data analysis. In FIGS. 13A and 14A, the abscissa indicates the time t. In FIGS. 13B and 14B, the abscissa indicates the frequency f.

FIG. 13A shows sinusoidal test data (model test data) having a period T, and FIG. 13B shows a fundamental wave of a frequency F which is obtained by discrete Fourier transform. The discrete Fourier transform can be described by the following formulas (1) and (2), where "a" indicates π and n indicates the number of data samples in terms $(j2a\pi t/n)$ and $(-j2a\pi t/n)$.

$$y(t) = (1/n) \sum_{f=0}^{n-1} Y(f) e^{(j2a\pi t/n)} \quad (1)$$

$$Y(f) = \sum_{t=0}^{n-1} y(t) e^{(-j2a\pi t/n)} \quad (2)$$

In addition, FIG. 14A shows a waveform of

the received test data, and FIG. 14B shows a result which is obtained by carrying out the discrete Fourier transform with respect to the waveform shown in FIG. 14A. In FIG. 14A, the waveform is distorted due to the quantization error and noise that is mixed. Hence, in the result shown in FIG. 14B, a large number of noise components appear on both sides of the fundamental wave of the frequency F along the frequency axis.

10 In the case of the test data analysis control shown in FIG. 11, the data analyzer 44 of the specified test data receiving office analyzes the test data by carrying out the discrete Fourier transform, and the analyzed results such as the results of the discrete Fourier transform shown in FIG. 14B are transmitted to the specified test data transmitting office. In this case, the comparison of the analyzed data and the threshold values and the judgement made on the comparison are made in the specified test data transmitting office.

20 FIGS. 15A, 15B, 16A and 16B are diagrams for explaining analysis and judgement of test data. In FIGS. 15A and 16A, the abscissa indicates the time t . In FIGS. 15B and 16B, the abscissa indicates the frequency f .

25 FIG. 15A shows sinusoidal test data (model test data) having a period T , and FIG. 15B shows a fundamental wave of a frequency F which is obtained by discrete Fourier transform. In FIG. 15B, it is assumed that a signal level S of the fundamental wave of the frequency F is "10".

35 FIG. 16A shows a waveform of the received test data, and FIG. 16B shows a result which is obtained by carrying out the discrete Fourier transform with respect to the waveform shown in FIG. 16A. In FIG. 16A, the waveform is distorted due to the quantization error and noise that is mixed.

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Hence, in the result shown in FIG. 16B, a large number of noise components appear on both sides of the fundamental wave of the frequency F along the frequency axis. In FIG. 16B, a signal level S' of the fundamental wave of the frequency F is "8", and a maximum noise level Nmax is "5". Of course, the levels of the fundamental wave and maximum noise vary depending on the degree of distortion of the received test data. In addition, in a state where the order wire line cannot be connected, the signal level S' of the fundamental wave of the frequency F becomes zero or close to zero.

FIG. 17 is a flow chart for explaining a judging logic. The judging logic shown in FIG. 17 includes a step A1 which starts judging the error in the setting and connection, and a step A3 which starts judging the quantization error. A step A2 decides whether or not $S'/S < W$, where S' indicates the signal level of the fundamental wave in the analyzed data which is obtained by carrying out the discrete Fourier transform with respect to the received test data, S indicates the signal level of the transmitted test data (model), W indicates a threshold value described by $W = (S - N_{\max})/S$, for example, and Nmax indicates the maximum noise level in the fundamental wave of the analyzed data. As described above, the test data to be transmitted are stored in the monitoring processor 9 or 39 of each transmission apparatus, and thus, the analyzed data may be obtained and prestored by analyzing in advance the prestored test data as the transmitting test data (model). In addition, the specified test data receiving office may return the analyzed data to the specified test data transmitting office, and the comparing and judging process may be carried out in the specified test data transmitting office.

The threshold value W which is used for

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the comparison and judgement satisfies $W \leq 1$, and is set to $W = (S - N_{\max})/S$ in this particular case. If $(S'/S) < W$, the signal level S' of the received test data is extremely low. Hence, if the decision result in the step A2 is YES, a step A6 judges that there is an error in the setting or connection such that the prearranged communication cannot be made via the order wire line. On the other hand, if the decision result in the step A2 is NO, it is judged that there is no error in the setting or connection, and the process advances to the step A3.

A step A4 decides whether or not conditions $S'/S < T$, $S'/N_{\max} < U$ and $N_{\max} > V \geq S$ are satisfied. In this case, T indicates a signal level with which the communication is possible and satisfies $T \leq 1$, U indicates a signal-to-noise ratio level with which the communication is possible, and V indicates an upper limit value of the noise level which is set. If none of the conditions are satisfied, that is, if all of the relations $S'/S < T$, $S'/N_{\max} < U$ and $N_{\max} \leq V$ simultaneously stand, the decision result in the step A4 is NO, and a step A5 judges that the quantization error is within a normal range, that is, no failure exists. On the other hand, if at least one of the conditions is not satisfied and the decision result in the step A4 is YES, a step A7 judges that the quantization error is large.

FIGS. 18A and 18B are diagrams for explaining judgement results. In a case where the analyzed results of the received test data are as shown in FIG. 18A, the results shown in FIG. 18B are obtained by setting the signal level S to $S = 10$ and setting the threshold values T , U , V and W to $T = 0.6$, $U = 1.5$, $V = 10$ and $W = (S - N_{\max})/S$, based on the judging logic described above. For example, in a case I, the analyzed data include $S' = 10$ and N_{\max}

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On the other hand, in a case II-1, the analyzed data include $S' = 5$ and $N_{\max} = 6$, and thus, it may be judged that there is no error in the setting or connection, since the relation $\{W = (10-6)/10 = 0.4\} < \{S'/S = 5/10 = 0.5\}$ stands. In addition, in the case II-1, it is judged that there is line noise caused by quantization error accumulation since $\{S'/S = 0.5\} < \{T = 0.6\}$. Moreover, it is judged that there is line noise caused by quantization error accumulation since $\{S'/N_{\max} = 5/6\} < \{U = 1.5\}$. It is judged that there is not error since $\{N_{\max} = 6\} < \{V = 10\}$. Therefore, based on the comparison and judgement made based on the analyzed data and the threshold values, it is judged that the line noise of the order wire line is increasing due to the quantization error accumulation.

30 In a case II-2, the analyzed data include
S' = 9 and Nmax = 20, and thus, it may be judged
that there is no error in the setting or connection,
since the relation $\{W = (10-20)/10 = -2\} < \{S'/S =$
 $9/10 = 0.9\}$ stands. In addition, in the case II-2,
35 it is judged that there is no failure since $\{S'/S =$
 $0.9\} > \{T = 0.6\}$. Moreover, it is judged that there
is line noise caused by quantization error

accumulation since $\{S'/N_{\max} = 9/20\} < \{U = 1.5\}$. It is judged that there is line noise caused by the quantization error accumulation since $\{N_{\max} = 20\} > \{V = 10\}$. Therefore, based on the comparison and judgement made based on the analyzed data and the threshold values, it is judged that the line noise of the order wire line is increasing due to the quantization error accumulation.

In a case III, the analyzed data include $S' = 0$ and $N_{\max} = 1$, and thus, it may be judged that there an error in the setting or connection, since the relation $\{W = (10-1)/10 = 0.9\} > \{S'/S = 0\}$. In other words, it is judged that an error exists in the setting or connection of the order wire line between the specified test data receiving office and the specified test data transmitting office. If a plurality of offices are connected between the specified test data transmitting office and the specified test data receiving office in this case III, it is possible to locate the office in which the error in the setting or connection exists, by successively specifying the test data receiving office.

In the case described above, the sinusoidal wave is used as the test data. However, when the DTMF signals from the office DTMF transmitting and retrieving section 37 are used as the test data, two frequency components are included in the test data. For this reason, when the data analysis is made by carrying out the discrete Fourier transform, a plurality of noise components will appear with respect to the fundamental waves of frequencies F_1 and F_2 . Accordingly, the comparison and judgement to determine the quality of the order wire line and the like may be made by using signal levels S_1 and S_2 of the fundamental waves of the test data model, signal levels S_1' and S_2' of the

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fundamental waves of the received test data, and the maximum noise level N_{max} .

It is also possible to use patterns of the DTMF signals as the test data. Such test patterns
5 may easily be generated by controlling the office DTMF transmitting and retrieving section 37 from the order wire monitoring controller 41. In this case, it is possible to monitor the order wire line based on the analyzed data of the test patterns and the
10 results of the discrete Fourier transform.

FIG. 19 is a time chart for explaining the operation of a test data receiving office. For the sake of convenience, the operation of the test data receiving office will be described by referring to
15 the construction shown in FIG. 9.

In FIG. 19, when the order wire monitoring controller 41 of the test data receiving office receives and identifies the control information specifying the test data receiving office, the order
20 wire monitoring controller 41 makes a setting so that the received test data can be stored in the received data storage section 42a, and the received data storage section 42a returns a setting complete to the order wire monitoring controller 41. The
25 order wire monitoring controller 41 returns the setting complete to the office which transmitted the control information which specifies the test data receiving office. The received test data received via the order wire line are stored in the received
30 data storage section 42a, and the stored test data are transferred to the data analyzer 43 when the reception of the test data ends. The data analyzer 43 makes the data analysis by carrying out the discrete Fourier transform or the like with respect
35 to the received test data, and stores the analyzed data indicative of the analyzed results into the analyzed data storage section 44. The stored

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When the analyzed data are stored in the analyzed data storage section 44 and the data analysis ends, the test data model stored in the received data storage section 42a or the transmitting data storage section 42b are transferred to the data analyzer 43. If a plurality of kinds of test data exist and the test data transmitting office selects and transmits the test data from the plurality of kinds, information which indicates the kind of test data is notified to the test data receiving office using the control information or the like. Hence, the test data receiving office can select, as the test data model, the corresponding kind of test data based on this notification from the test data transmitting office, and transfer the test data model to the data analyzer 43. In this case, the data analyzer 43 of the test data receiving office can analyze the test data model similarly to analyzing the received test data, by carrying out the discrete Fourier transform or the like. In the test data receiving office, the analyzed data indicative of the analyzed results are stored in the analyzed data storage section 44, and the stored analyzed data are transferred to the comparing and judging section 45. Of course, it is possible to prestore the analyzed data with respect to the test data model.

30 In the test data receiving office, the
comparing and judging section 45 compares and judges
the analyzed results of the test data model
(transmitted test data) and the received test data,
similarly as described above, and judges whether or
35 not an error exists in the setting or connection of
the order wire line, and whether or not line noise
exists due to quantization error accumulation.

Judgement results of the comparing and judging section 45 are transmitted from the order wire monitoring controller 41 as control information, to the test data transmitting office or the office to which the monitoring control terminal TE is connected.

Of course, it is possible to appropriately combine the embodiments described above to achieve the object of the present invention. The application of the present invention is also not limited to the systems described above, and the present invention may similarly be applied to various kinds of network systems formed by transmission apparatuses which carry out the prearranged communication.

In addition, if a monitoring control terminal is connected in advance to each transmission apparatus, it is possible to test the order wire line between desired transmission apparatuses from an arbitrary transmission apparatus. An order wire monitoring method according to the present invention may employ such an arrangement or, any one or combination of the embodiments described above.

Further, the present invention is not limited to these embodiments, but various variations and modifications may be made without departing from the scope of the present invention.